

UNCERTAINTY ESTIMATE

For Calibration Procedure for Optronics OL 83A Programmable Current Source

Shunt Resistor Error

The standard resistor used as a current shunt is a calibrated Leeds & Northrup Model 4222-B, Serial Number 1921670. At the time of last calibration, August 1988, the resistance measured $0.00999999\Omega \pm 0.001\%$ @ 25°C . To meet the calibration report limit of error, the current through the resistor must not exceed 10.0A.

Three main error sources are resistance uncertainty, r_{error} , resistance drift, r_{drift} , and temperature error, t_{error} .

Resistance uncertainty is specified by the resistor calibration report, $r_{\text{error}}=0.001\%$.

The resistance drift estimate is based on the 0.001% / year stability statement in the resistor calibration report.

$$r_{\text{drift}} = (0.001\%/ \text{year}) \times 11 \text{ years} = 0.011\%$$

A thermal correction equation and parameters are supplied as part of the resistor calibration report. Using this equation, a correction for temperature induced resistance changes can be applied. The thermal error, t_{error} , results from the uncertainty between the measured and actual resistor temperature.

During this OL 83A calibration, resistor temperature corrections were not applied, since resistor temperature could not be measured, and ambient temperature measurements are not of practical use for generating thermal compensation coefficients. Therefore, a conservative thermal error assumption is defined as double the correction of the 3°C difference between ambient (22°C) and resistance calibration temperatures (25°C).

$$t_{\text{error}}=0.00206\%$$

Total resistor error is defined as the RMS of the components:

$$E_{\text{resistor}} = \sqrt{r_{\text{error}}^2 + r_{\text{drift}}^2 + t_{\text{error}}^2} = \sqrt{0.001^2 + 0.011^2 + 0.00206^2} = 0.0112358\%$$

Instrument Error

Instrument error is defined as the sum of the reading and range errors.

Reading error is defined as:

$$E_s = (I_1 + N) \times r$$

Where I_1 is a characteristic instrument error provided in the instrument specifications, N is the NIST traceability error, and r is the reading.

Range error is defined as:

$$E_R = (I_2 + S) \times R$$

Where I_2 is a characteristic instrument range error provided in the instrument specifications, S is any additional systematic errors outlined in the instrument specifications, and R is the range. I_2 may be different for different ranges. Instrument configuration at the time of measurements defines the systematic errors included in S.

The current measurement configurations measure the voltage drop across the calibrated shunt resistance from which the current is calculated.

$$E_{i=4.000A} = E_S + E_R = \frac{(2.5 \times 10^{-6} + 2 \times 10^{-6})0.04 + (3 \times 10^{-6} + 17 \times 10^{-6})0.1}{0.04} = 0.0000545\%$$

$$E_{i=8.000A} = E_S + E_R = \frac{(2.5 \times 10^{-6} + 2 \times 10^{-6})0.08 + (3 \times 10^{-6} + 17 \times 10^{-6})0.1}{0.08} = 0.0000295\%$$

Voltage calibration requires measurement of the voltage drop across the load lamps.

$$E_{v=60.0V} = E_S + E_R = \frac{(2.5 \times 10^{-6} + 2 \times 10^{-6})60 + (0.3 \times 10^{-6} + 17 \times 10^{-6})100}{60} = 0.0000333\%$$

$$E_{v=120.0V} = E_S + E_R = \frac{(2.5 \times 10^{-6} + 2 \times 10^{-6})120 + (0.1 \times 10^{-6} + 29 \times 10^{-6})1000}{120} = 0.000247\%$$

Total Error

Total error for current measurements is defined as the RMS of the resistor and instrument errors, resulting in a different error for each calibration point.

$$E_{TOTAL @ 4.000A} = \sqrt{E_{resistor}^2 + E_{i=4.000A}^2} = \sqrt{0.0112358^2 + 0.0000545^2} = 0.0112359\%$$

$$E_{TOTAL @ 8.000A} = \sqrt{E_{resistor}^2 + E_{i=8.000A}^2} = \sqrt{0.0112358^2 + 0.0000295^2} = 0.0112359\%$$

Total error for voltage measurements consists of instrument error only.

$$E_{@60.0V} = 0.00003\%$$

$$E_{@120.0V} = 0.00025\%$$

In the CF, the usual application of the OL 83A power supply is to power a standard lamp at 8.20 A. Therefore, errors other than that at the 8.000 A calibration point are not of interest.